Vibration in Army Aviation
U3004518 / Version 1
19 Aug 2003

SECTION I. ADMINISTRATIVE DATA

All Courses Including This Lesson

Course Number	Version	Course Title

Task(s) Taught(*) or Supported

Task Number	Task Title

Reinforced Task(s)

Task Number	Task Title

Academic Hours

The academic hours required to teach this lesson are as follows:

	Resident Hours/Methods
	40 mins / Conference / Discussion
Test	0 hrs
Test Review	0 hrs
Total Hours:	40 mins

Test Lesson Number

	Hours	Lesson No.
Testing (to include test review)		N/A

Prerequisite Lesson(s)

Lesson Number	Lesson Title
None	

Clearance Access

Security Level: Unclassified
Requirements: There are no clearance or access requirements for the lesson.

Foreign Disclosure Restrictions

FD5. This product/publication has been reviewed by the product developers in coordination with the USASAM foreign disclosure authority. This product is releasable to students from all requesting foreign countries without restrictions.

References

Number	Title	Date	Additional Information
0-7817-2898-3	Fundamental of Aerospace Medicine, 3rd Edition		
AR 40-501	Standards of Medical Fitness	30 Sep 2002	
FM 3-04.301	Aeromedical Training for Flight Personnel	29 Sep 2000	
TB MED 501	(SS/DA Pam 40-501, Aug 91) Occupational & Environmental Health:Hearing Conservation	15 Mar 1980	
TG 170	(SS/DA Pam 40-501) Hearing Conservation		

Student Study Assignments

Study student handouts and required reference materials

Instructor Requirements

One 91W3F instructor or 67J, and one Guest Speaker Audiologist for ELO 3.

Additional Support Personnel Requirements

Name	Stu Ratio	Qty	Man Hours
None			

Equipment Required for Instruction

Id Name	Stu Ratio	Instr Ratio	Spt	Qty	Exp
279JK11 INSTRUCTOR WORKSTATION COMPUTER PROCESSING UNIT PRECIS GX 240	1:50	1:!	No	0	No

* Before Id indicates a TADSS

Materials Required

Instructor Materials: None
Student Materials:
Student handout

Classroom, Training Area, and Range Requirements

Ammunition Requirements

Id	Name	Exp	Stu Ratio	Instr Ratio	Spt Qty
None					

Instructional

NOTE: Before presenting this lesson, instructors must thoroughly prepare by

Guidance	studying this lesson and identified reference material. Ensure to arrange for Audiologist.

Proponent Lesson Plan Approvals	**Name**	**Rank**	**Position**	**Date**
	Sherman, Michael			
	Gordon, William			
	Houser, Joseph			
	Campbell, John			

SECTION II. INTRODUCTION

Method of Instruction: Conference / Discussion
Instructor to Student Ratio is: 1:50
Time of Instruction: 5 mins
Media: Large Group Instruction

Motivator

As air crewmembers, we operate in an environment that exposes us to hazardous noise and vibration levels on a daily basis. Noise and vibrations affect certain aspects of flight such as effective cockpit communications. Vibrations can affect coordination, vision and can cause performance degradation while engaged in other flight related activities. Proper management of the effects of noise and vibrations can enhance cockpit performance, promote a safe flying environment and ensure successful execution of the mission.

Terminal Learning Objective

NOTE: Inform the students of the following Terminal Learning Objective requirements.

At the completion of this lesson, you [the student] will:

Action:	Manage the effects of noise and vibrations in Army aviation
Conditions:	While performing as an aircrew member.
Standards:	IAW FM 3-04.301 (FM 1-301), AR 40-501, DA PAM 40-501 and Fundamentals of Aerospace Medicine

Safety Requirements

None

Risk Assessment Level

Low

Environmental Considerations

NOTE: It is the responsibility of all soldiers and DA civilians to protect the environment from damage.
None

Evaluation

Instructional Lead-In

During initial aviator training phase, you will learn about human factors during flight. Today's training will provide you with the foundation needed to be familiar with the effects of noise and vibration and their impact in the aviation environment

SECTION III. PRESENTATION

NOTE: Inform the students of the Enabling Learning Objective requirements.

A. ENABLING LEARNING OBJECTIVE

ACTION:	Manage the effects of vibration in Army Aviation
CONDITIONS:	While performing as an aircrew member
STANDARDS:	IAW FM 3-04.301 (FM 1-301), AR 40-501, DA PAM 40-501 and Fundamentals of Aerospace Medicine

1. Learning Step / Activity 1. Identify vibration terminology

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 0 hrs
Media: Large Group Instruction

NOTE: PowerPoint slides 70 through 77.

a. Vibration is the motion of an object relative to a reference position (usually the object at rest) involving a series of oscillations resulting in the displacement and acceleration of the object.

b. Frequency is the number of oscillations of any object in a given time measured in cycles per second (cps). The international standard unit of frequency is the hertz (Hz). (1 cps equal 1 Hz).

c. Amplitude is the maximum displacement of an object from its position at rest.

d. Duration is the amount of time exposed to vibration.

e. Natural body resonance is the mechanical amplification of vibration by the body occurring at specific frequencies.

f. Damping is the loss of mechanical energy in a vibrating system. This causes the vibration to slow down.

(1) When the body is subjected to certain frequencies, the tissue and organs will begin to resonate (increase in amplitude).

(2) The connective tissue (muscle, tendons and ligaments) that binds the major organs together reacts to vibrations like a shock absorber.

(3) The reason why humans do not receive life-threatening injuries every time they go flying is due to the minor amplitudes of the vibration in the aircraft and the ability of the body to provide some damping against those vibrations

NOTE: Conduct a check on learning and summarize the learning activity.

2. Learning Step / Activity 2. Identify the sources of vibration

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 0 hrs
Media: Large Group Instruction

NOTE: PowerPoint slides 78 through 81.

a. Vibrations are produced within the aircraft and the environment in which the aircraft operates.

(1) Vibrations within the aircraft originate primarily from the engines, the main rotor, and the tail rotor system. The following table shows the estimated frequencies for an UH-1 helicopter:

UH-1

COMPONENT	FREQUENCY
Engine	**110 Hz**
Main Rotor	**4-11 Hz**
Tail Rotor	**30-60 Hz**

(2) Increased airspeed, internal and external loading of the aircraft can also cause vibrations.

(3) Environmental factors such as turbulence may also intensify vibrations.

(4) Helicopter vibrations occurs with similar intensities in all three axes of motion, (**X,Y,Z**).

b. The amplitude of the vibration differs in each mode of flight. The highest level of vibration occurs during the transition from flight to a hover and hover to flight.

NOTE: Conduct a check on learning and summarize the learning activity.

3. Learning Step / Activity 3. Identify the effects of vibration on human performance during flight

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 0 hrs
Media: Large Group Instruction

NOTE: PowerPoint slides 82 through 86.

a. Vibration affects the aircrew member's ability to perform simple tasks during flight.

b. Manual coordination and control "touch" is degraded at 4-8 Hz. Pilot induced oscillations occur when the aircrew member over controls during turbulence and/or transition from a hover to flight.

c. Vision could be affected due to vibration in the aircraft, visual instruments may be difficult to read. Helmet mount or night vision devices may vibrate at 4-12 Hz.

d. Speech can be distorted during oscillations of 4-12 Hz. Above 12 Hz, speech becomes increasingly difficult to interpret.

NOTE: Conduct a check on learning and summarize the learning activity.

4. Learning Step / Activity 4. Identify the short term effects of vibration

Method of Instruction: Conference / Discussion
Instructor to Student Ratio: 1:50
Time of Instruction: 0 hrs
Media: Large Group Instruction

NOTE: PowerPoint slides 87 through 95.

CAUTION: Vibration can cause short-term effects because of the body's mechanical properties.

a. The human body acts like a series of objects connected by springs.

(1) The connective tissues that bind the major organs together react to vibration in the same way as springs.

(2) When the body is subjected to certain frequencies, the tissue and organs will begin to resonate (increase in amplitude).

(3) When objects reach their resonant frequencies, they create a momentum, which increases in intensity with each oscillation.

(4) Without shock absorption, vibration will result in damage to the mass or object.

b. Helicopters subject aircrew members to vibrations over a frequency range that coincides with the resonant frequencies of the body. Prolonged contact with vibration causes short-term effects to the body. The reason why humans do not receive life-threatening injuries every time they go flying is due to the minor amplitudes of the vibration in the aircraft and the ability of the body to provide some damping against those vibrations.

BODY PART	RESONANT FREQUENCY
Whole Body	4-8 Hz
Shoulder girdle	4-8 Hz
Head	25 Hz
Eyes	30-90 Hz

c. Fatigue.

(1) Vibration causes the body's muscle groups to make reflex contractions.

(2) When the human body is in motion, pressure receptors located in tendons and muscles constantly measure angular position of the muscles so as to maintain posture and balance.

(3) These receptors respond to vibration causing contraction or tightening of the muscle. For example, vibration placed on both calves of a standing subject resulted in the subject experiencing the sensation of leaning forward.

d. Respiratory effects.

(1) Hyperventilation is caused when the diaphragm is vibrated at its resonant frequency of 4-8 Hz.

(2) The result of vibrating frequencies in the diaphragm will cause “artificial respiration”.

e. Circulatory effects. Increase in pulse rate and blood pressure are other symptoms of exposure to vibration.

f. Motion sickness.

(1) Vibration with a frequency of less than 1 Hz (slow rolling of a ship) can produce nausea in susceptible people.

(2) The Neural Mismatch Theory postulates that there is a long term memory storage of the “correct world,” in terms of movement as a terrestrial being, which is matched against the actual conditions. When these perceptions do not match, then the brain perceives an imbalance and initiates a reflex response in the stomach. It is a theory that motion sickness stems from the innate response humans have when confronted with the neural mismatch, caused by the poison, seeks to rid the body of the poison by vomiting.

g. Disorientation. Vibration affects the semicircular canals and the Otolith organs, which in turn respond to the changes in angular and linear motions.

h. Pain usually results from pre-existing injuries received before flying, such as stress fractures, and other traumas. Vibration aggravates those conditions.

NOTE: Conduct a check on learning and summarize the learning activity.

5. Learning Step / Activity 5. Identify the long term effects of vibration

Method of Instruction:	Conference / Discussion
Instructor to Student Ratio:	1:50
Time of Instruction:	0 hrs
Media:	Large Group Instruction

NOTE: PowerPoint slides 96 through 100.

CAUTION: Long-term exposure to vibration over a period of time may cause injury to air crewmembers.

a. Raynaud’s Disease (White finger) occurs to the hands after prolonged exposure to vibration from power tools, jackhammers, or other such equipment that vibrates at high frequencies. Trauma occurs in the arterioles and nerve endings in the extremities and limits the blood flow to that portion of the extremity.

b. Backache/back pain in aircrew member may result at an earlier age than normal.

(1) The lumbar spine, in particular, is subjected to higher pressures during aircraft operation because the weight of the torso on that part of the spine while sitting. When the body is standing, the legs support most of the body's weight.

(2) Bone, like other organs, requires blood to provide nutrients for life. When the spine is subjected to high levels of vibration, blood flow is reduced. The reduction in blood flow results in premature degeneration of bone structures within the spine.

(3) If you bend steel back and forth enough times, you can produce a weak section, which will eventually break. This same principle can be applied in understanding injuries to the spine.

c. Kidney and lung damage. Currently under scientific study, the effects of vibration on the functions of other organs include:

(1) Signs of overexposure to vibration may be blood in the urine (kidney).

(2) Lung damage may result after prolonged exposure to vibration at resonant frequencies.

NOTE: Conduct a check on learning and summarize the learning activity.

6. Learning Step / Activity 6. Identify the method(s) used to reduce the vibrational threat in Army aviation

Method of Instruction:	Conference / Discussion
Instructor to Student Ratio:	1:50
Time of Instruction:	0 hrs
Media:	Large Group Instruction

NOTE: PowerPoint slides 101 through 106.

a. Vibration cannot be eliminated, but its effects on human performance and physiological functions can be lessened.

b. Maintain good posture during flight. Sitting straight in the seat will enhance blood flow throughout the body.

c. Restraint systems provide protection against high magnitude vibration experienced in extreme turbulence.

WARNING: Body supports such as lumbar inserts and seat Cushions reduce discomfort and can dampen vibration; however, during a crash sequence they may increase the likelihood of injury due to their compression characteristics.

d. Maintain your equipment. Proper aircraft maintenance such as blade tracking can reduce unnecessary vibration exposure.

e. Isolate the aircrew members or passengers. When loading patients on MEDEVAC aircraft, remember that patients placed on the floor will experience more vibration than the one on the litter support system.

f. Limit your exposure time. Make short flights with frequent breaks, rather than one long flight, if mission permits.

g. Let the aircraft do the work. Do not grip the controls tightly. Vibration can be transmitted through control linkages during turbulence.

h. Maintain excellent physical condition. Fat multiplies vibration, while muscle dampens vibration. Strong muscles act to reduce the magnitude of oscillations encountered in flight (damping). An overweight aircrew member is more susceptible to decrements in performance and the physiological effects to vibration.

(1) Maintaining good physical condition lessens the effects of fatigue. Good physical condition permits you to continue to function during extended combat operations with minimum rest. Energy and alertness is what keeps you alive.

(2) Maintain sufficient hydration. Drink plenty of fluids, even if you don't feel thirsty, a minimum of two quarts of water over and above fluids taken with meals. Dehydration coupled with vibration can cause fatigue twice as fast and it will take double the time needed for recovery.

NOTE: Conduct a check on learning and summarize the learning activity.

CHECK ON LEARNING: Conduct a check on learning and summarize the ELO.

SECTION IV. SUMMARY

Method of Instruction: Conference / Discussion
Instructor to Student Ratio is: 1:50
Time of Instruction: 5 mins
Media: Large Group Instruction

Check on Learning

Determine if the students have learned the material presented by soliciting student questions and explanations. Ask the students questions and correct misunderstandings.

QUESTION: Select the definition of sound.

ANSWER: Sound is mechanical radiant energy that is transmitted by longitudinal pressure waves in a material medium(as air) and is the objective cause of hearing.

QUESTION: Select the definition of noise.

ANSWER: Noise is defined as sound that is loud, unpleasant, or unwanted, however, the sound does not have to be loud to be considered a noise.

QUESTION: Select the three measurable characteristics of noise.

ANSWER: Frequency, intensity, and duration

QUESTION: Select the types of hearing loss associated with prolonged exposure to noise.

ANSWER: Conductive loss, presbycusis loss, and sensorineural hearing loss.

QUESTION: What are three sources of vibration within the aviation environment?

ANSWER: Aircraft, environment, and other sources.

QUESTION: What are the three ways vibration affects human performance?

ANSWER: Manual coordination, vision, and speech.

QUESTION: How can you limit your exposure time?

ANSWER: Make shorter flights and limit exposure time removal from source.

3. TRANSITION TO THE NEXT LESSON. This lesson is the second in your course of instruction of aviation medicine. You should now be prepared to take the one-hour exam.

Review / Summarize Lesson

SECTION V. STUDENT EVALUATION

Testing Requirements	**NOTE:** Describe how the student must demonstrate accomplishment of the TLO. Refer student to the Student Evaluation Plan.
Feedback Requirements	**NOTE:** Feedback is essential to effective learning. Schedule and provide feedback on the evaluation and any information to help answer students' questions about the test. Provide remedial training as needed.

Appendix A - Viewgraph Masters (N/A)

Appendix B - Test(s) and Test Solution(s) (N/A)

Appendix C - Practical Exercises and Solutions (N/A)

Appendix D - Student Handouts (N/A)